Right axillary incision: A cosmetically superior approach to repair a wide range of congenital cardiac defects

René Prêtre, MD,[a] Alexander Kadner, MD,[a] Hitendu Dave, MD,[a] Ali Dodge-Khatami, MD, PhD,[a] Dominique Bettex, MD,[b] and Felix Berger, MD[c]

Prêtre, Bettex, Kadner, Dave, Dodge-Khatami *(left to right)*

Objectives: We sought to evaluate the safety of a right axillary incision, a cosmetically superior approach than anterolateral thoracotomy, to repair various congenital heart defects.

Methods: All the patients who were approached with this incision between March 2001 and October 2004 were included in the study. There were 80 patients (median age, 4 years) with atrial septal defect closure (38 patients), repair of partial abnormal pulmonary venous return (14 patients), partial atrioventricular canal (16 patients), and perimembranous ventricular septal defect (12 patients). The surgical technique involved peripheral and central cannulation for institution of cardiopulmonary bypass. Electrically induced ventricular fibrillation was used for defects located in front of the atrioventricular valves, and cardioplegic arrest was used for those located at the level or behind these valves.

Results: The repair was possible without need for conversion to another approach. One patient sustained a transient neurologic deficit. The patients were all in excellent condition after a mean follow-up of 14 months. The cardiac defect was repaired with no residual defect in 75 patients and with trivial residual defect in 5 patients (3 with mitral valve regurgitation, 1 with atrial septal defect, and 1 with ventricular septal defect). The incision healed properly in all, and the thorax showed no deformity.

Conclusion: The right axillary incision provides a quality of repair for various congenital defects similar to that obtained by using standard surgical approaches. Because it lies more laterally and is hidden by the resting arm, it provides superior cosmetic results compared with conventional incisions, including the anterolateral thoracotomy. Finally, the incision is unlikely to interfere with subsequent development of the breast.

From Pediatric Cardiac Surgery,[a] Anesthesia,[b] and Cardiology,[c] Department of Surgery, University Hospital Zurich, Zurich, Switzerland.

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Address for reprints: René Prêtre, MD, Department of Surgery, University Hospital Zurich, 100 Ramistrasse, Zurich 8091, Switzerland (E-mail: rene.pretre@usz.ch).

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The priority of surgical intervention in the management of congenital heart defects is the accomplishment of a perfect repair that ensures the longest life expectancy and best quality of life, and minimizes the risk of natural complications. Simple heart defects, especially those located at the atrial level, are today corrected with a morbidity rate approaching zero.[1-3] Criticisms regarding conventional surgical repair have always focused on the use of the heart-lung machine and on the use of visible, at times psychologically upsetting incisions. These facts have stimulated the development of alternative approaches like catheter-based repairs, which result in cosmetically excellent results but at the expense of frequent residual defects.[4,5] The pressure for a cosmetic approach is at times so great that some patients or their parents or cardiologists are ready to accept a percutaneous approach in nonoptimal situations.

The right anterolateral thoracotomy, an approach once judged cosmetically superior to a sternotomy, has led to less optimal than expected results, mainly

Figure 1. Postoperative result of the skin incision used in conjunction with a groin incision for the correction of an abnormal return of the right upper pulmonary veins.

Figure 2. Result after the closure of a restrictive perimembranous VSD.

because of subsequent deformation of the thoracic cage (caused by rib deformation and atrophy of the severed pectoral muscles) and asymmetric development of the breasts when used in prepubescent girls.[6] Since 2001, we have used an axillary incision to repair atrial septal defects (ASDs). With the accumulation of experience, the use of the incision was extended precociously to other simple heart defects and turned out to be safe. Because of its location in an area free from thoracic wall muscles and away from the breast bud, the incision should not lead to subsequent asymmetric growth of the chest or breast. Finally, the incision, which is hidden by the resting arm, results in an almost invisible scar. The excellent cosmetic results and applicability to other cardiac defects make this approach particularly attractive in children.

Patients and Methods

The series includes 4 groups of patients with different diagnoses. Once confidence in the surgical technique of a defect was gained, a group with incremental difficulty in surgical repair was approached. The series relates to consecutive patients operated on by one surgeon (R.P.) from March 2001 through October 2004. Chronologically, the technique was started in March 2001 for closure of ASD, in July 2001 for the repair of ASD with partial abnormal pulmonary venous return (in the superior vena cava [SVC], Figure 1), in March 2002 for the repair of partial atrioventricular canal, and in September 2003 for the closure of restrictive perimembranous ventricular septal defect (VSD; Figure 2). No patient with these diagnoses had another surgical approach to their defects during these time frames. Demographic and clinical data of the patients are summarized in Table 1.

Quality of the repair was assessed by transesophageal echocardiography during the operation and by transthoracic echocardiography during the hospital stay and at the first outpatient follow-up visit after 3 months. These data and the clinical status at 3 months were available in all the patients. Follow-up was complete and ranged from 1 month to 3.5 years (median, 14 months).

Position of the Patient and Axillary Incision

An echocardiographic probe was inserted in the esophagus in all patients. The patients were positioned with the chest in an 80° left lateral position and the pelvis in a corresponding 45° position. The right arm was brought over the head and supported by a sling. The anterior axillary line was marked with a pen (as anterior limit for the incision), as was the fourth intercostal space. A 4- to 5-cm incision was made, the subcutaneous tissue was undermined, the anterior border of the latissimus dorsi was set free of attachments, and the muscle was mobilized to expose the fifth rib. The approach to the rib was made anterior to the neurovascular pedicle of the long thoracic artery and nerve. A retractor (Langenbeck retractor) was inserted underneath the latissimus dorsi to retract both structures together to free the rib posteriorly and thereby avoid injury to the pedicle. The periostium was separated from the rib, and the pleura was entered in the fourth intercostal space through a subperiosteal route. If access to the pericardium was easy at that time, it was opened parallel, 1 inch anterior to the phrenic nerve. Otherwise, it was opened after cardiopulmonary bypass (CPB) had been established and the right lung had been deflated. Once CPB

TABLE 1. Demographic and operative data

	No. of patients	Median age (y)	Median weight (kg)	Median VF or CA time (min)	Median CPB time (min)
ASD	38	4.2 (1.5-13)	15 (9.4-45)	12 (VF)	45
pARPV	14	6.3 (3.5-11.5)	19 (12.6-34)	27 (VF)	91
pAV canal defect*	16	8.8 (1.6-12.3)	23 (8.5-46)	33 (CA)	89
VSD†	12	6.7 (5.3-20)	21 (18-62)	32 (CA)	91

CPB, Cardiopulmonary bypass; *ASD*, atrial septal defect; *pARPV*, partial abnormal return of the pulmonary veins; *pAV*, partial atrioventricular; *VSD*, ventricular septal defect; *VF*, ventricular fibrillation; *CA*, cardioplegic arrest. *Three patients underwent concomitant posterior annuloplasty of the left atrioventricular valve. †Two patients underwent concomitant repair of the aortic valve.

was established, ventilation was reduced, and the SVC was dissected, snared, and cannulated (it has never been drained by percutaneous cannulation of the internal jugular vein).

Iliac Vessel Cannulation

This approach has been used in the great majority of our patients (70 patients) and has provided excellent hemodynamic parameters. The youngest patient with cannulation of the iliac artery was 3 years of age and weighed 12 kg. A short incision was made in the skin line above the femoral ligament. The aponeurosis of the external oblique was opened along its fibers. The insertion of the internal oblique and fascia transversalis on the inguinal ligament was divided, and the external iliac vessels (which are at this point extremely superficial) were dissected and looped. The sensory nerves that course over the internal oblique were thus never disturbed. The iliac vein was clamped and opened with a sharp incision. A simple thoracic drain (16F for children $<$20 kg and 20F for children $>$20 kg) was inserted and pushed toward the right atrium. A simple loop of silk, snared around the cannulated vein, prevented any loss of blood and permitted subsequent adjustment of the position of the cannula. The artery was clamped, opened transversally with a scalpel, and gently dilated with a small mosquito clamp. A Bard arterial cannula (C.R. Bard, Inc) was used for arterial cannulation. At the end of CPB, the artery was repaired with interrupted resorbable stitches, and the vein was repaired with a running suture.

The heart-lung machine was brought close to the groin on the right side of the patient to have the shortest possible lines to reduce the loss of pressure and energy. A vacuum (10-25 mm Hg) was set on the venous return to improve return and reduce the risk of air blockage. The position of the heart-lung machine close to the patient, the iliac venous cannula having almost only a descending course, and the low suction on the vein allowed us frequently to avoid snaring the inferior vena cava.

In 10 patients the ascending aorta was used for arterial cannulation. In the patients weighing less than 12 kg (6 with ASD and 2 with partial atrioventricular canal), it was feared that the iliac artery would be too small to achieve correct flow. In 2 other patients, both with a restrictive VSD, the access to the aorta was gained through the third intercostal space. In both cases, the position of the ascending aorta allowed easy cannulation and crossclamping. Our cannulation site of choice, however, remains the iliac vessels.

Myocardial Perfusion

Ventricular fibrillation and cardioplegic arrest have been used.

1. Ventricular fibrillation was used for the closure of ASDs and the repair of partial abnormal pulmonary venous return. Ventricular fibrillation was the simplest technique because the aorta was not crossclamped, and delivery of cardioplegia could be avoided. Once full CPB had been established (either at normothermia or slight hypothermia), a fibrillator pad was secured on the right ventricle with a stitch, and ventricular fibrillation was induced electrically. The right atrium was opened and maintained open with 3 stay sutures. The tip of the inferior venous cannula was positioned to obtain the best drainage, and a cardiotomy sucker was used to optimize vision. If the left ventricle was seen beginning to dilate on transesophageal echocardiography, the mitral valve was briefly opened with the tip of the cardiotomy sucker. When the maneuver was performed swiftly, no air entered the left ventricle, and the ventricle was efficiently decompressed. Because of the continuous contact of air with blood coming mostly from the coronary sinus, carbon dioxide was not insufflated to avoid excessively high content of carbon dioxide in blood.

2. Cardioplegic arrest of the heart (with venting of the left ventricle) was used for the correction of partial atrioventricular canal defects and VSD. Iliac vessel cannulation was preferred to reduce the number of cannulas present in the axillary incision. The inferior vena cava was snared in these patients. A 2-stage approach with the third and fourth intercostal spaces was used at the level of the thoracic wall. The aortic cannula (if present), the SVC cannula, the cardioplegic line, and the aortic crossclamp were brought out through the third intercostal space. The left ventricular vent was inserted in the right superior pulmonary vein through the fourth intercostal space. The VSD or mitral valve was repaired through the fourth intercostal space. The aortic valve (if repair was needed) was approached through the third intercostal space. Carbon dioxide was insufflated though the axillary incision until the atrial and ventricular septa were closed.

Surgical Technique

The ostium secundum and primum defects were closed directly[7] in 28 and 15 patients and with a patch of autologous pericardium in 5 and 1 patients, respectively. Sinus venosus defects were closed either with a pericardial patch (3 patients) or directly after mobilization of a redundant septum secundum (2 patients). Abnormal return of the right superior pulmonary vein in the SVC was corrected by routing the caudal end of the SVC through the ASD

to the left atrium with a baffle patch (this part was performed during induced ventricular fibrillation) and direct reimplantation of the cranial end of the SVC in the right atrial appendage (this part was performed on a beating heart). The mitral valve was reconstructed with closure of the cleft in all patients with an atrioventricular canal defect and with a posterior annuloplasty in 3 patients with concomitant annular dilatation. Annuloplasty was performed with running sutures of resorbable material on the posterior annulus in the same way as a DeVega plasty for the tricuspid valve.[8] The VSD was approached directly in 7 patients and after detachment of the anterior leaflet of the tricuspid valve in 5 patients.[9] It was closed directly in 8 patients and with a patch of xenopericardium in 4 patients. A plasty of the anteroseptal commissure of the tricuspid valve was performed in 9 patients with concomitant tricuspid valve insufficiency. Two patients in the VSD group had resuspension of a prolapsing right coronary leaflet of the aortic valve (by using a transverse aortotomy), and 1 patient had resection of a subaortic membrane. The membrane, which was confined to the septum and lateral part of the anterior leaflet of the mitral valve, was removed completely with sharp and blunt dissection through the VSD.

Results

The surgical repair was possible with an axillary incision in all patients. No conversion to another incision was necessary. A second run on CPB was necessary in 3 patients because of an additional ASD (2 patients) that had been overlooked and because of a residual VSD (1 patient).

There was no mortality during hospital stay or thereafter. There was no reoperation and no need for pacemaker insertion. Significant morbidity occurred in 1 patient with ASD closure (patient 18 in our series). A sudden hemiparesis of the left arm occurred on the second postoperative day, 1 day after extubation and initial normal neurologic assessment. Magnetic resonance imaging detected an ischemic injury in the right cerebral hemisphere consistent with an embolus. The deficit regressed within 2 days.

Correction of the cardiac defect was judged to be excellent and potentially definitive in 75 patients. Five patients had trivial residual defects detected on echocardiography. Three patients had minimal central mitral valve regurgitation, 1 patient had a small residual ASD, and another patient had a small residual VSD. In these patients the repair was also judged to be potentially definitive, although regular follow-up evaluations are needed to ascertain stability or regression of the defect. The thoracic and the inguinal incisions healed properly in all patients. No patients showed inguinal lymphorrhea, and all had symmetric peripheral pulses.

Discussion

Most surgical corrections performed at the atrial level are considered simple and should lead to a perfect repair with an uneventful course. The cosmetic aspect of a heart operation is seldom taken into consideration in view of the importance of achieving a safe and reliable cardiac repair, the quality of which not only affects the patient's life expectancy but also his or her life quality. If the same quality of repair, however, can be obtained with a cosmetically superior approach, many patients will opt for such an alternative. To some extent, this attitude has popularized the percutaneous approach to close simple atrial defects.[4,5] The pressure for a cosmetic approach is at times so great that some patients or their parents were ready to accept increased risks or less optimal results.

The psychological burden of a full sternotomy should not be underestimated in children, teenagers, and young adults. The corporeal image is especially important at this time of life to promote positive self-esteem, and a deprecated image might lead to reactions of retreat or even depression. Finally, the conspicuous sternal incision is a lifelong reminder of a "heart problem" not only to the patient but to his entourage as well. This is certainly why the anterolateral incision, even when it had resulted in thorax and breast deformity, was better accepted than the median sternal incision.[3,6,10] The view of an incision on the right side of the chest, especially when it lies underneath the armpit, as in our patients, does not trigger the label "heart problem." Finally, the incision in the axilla is simply invisible as long as the arm is not abducted.

The axillary approach appears to be a good alternative to other chest incisions, including the anterolateral thoracotomy. It allows the safe correction of a wide range of cardiac defects and results in a cosmetically acceptable and almost invisible scar. The thorax showed no asymmetry postoperatively and during follow-up. The growth of the musculoskeletal elements of the thoracic wall appeared normal, probably because we spared the thoracic muscles and retained a normal space between the ribs. This is in contrast to the muscle atrophy noted on the pectoralis muscles and sometimes to the rib deformity observed after the anterolateral incision.[6] The axillary part of the ribs is midway between the anterior and posterior hinge points. The ribs and their attachments are thus minimally stressed when spread apart at this point. This is probably the reason why, in our experience, the ribs were never broken or disinserted at the chondrocostal junction. We also hope that the breasts will develop harmoniously in female patients because of our efforts never to cross the anterior axillary line and therefore never to violate the borders of the mammary gland.

As a matter of fact, when the ventricular fibrillation method was used (as was the case in ostium secundum closure), the anterior limit of the incision remained well 1 to 2 cm posterior to the anterior axillary line. Recently, we have also used a purely vertical incision along the midaxillary line. Because of the extreme elasticity of the axillary skin, the access to the heart was identical to an incision parallel to the ribs within the skin folds.

Asymmetric development of the chest and breast after anterolateral thoracotomy[3,6] has convinced many groups to abandon the incision in favor of a partial inferior sternotomy, at times limited to the xyphoid process.[11,12] We have been using this approach to repair isolated VSD in infants since 2001. Although the cosmetic result is superior to that with a full sternotomy, it is far from that obtained with the axillary incision. The axillary incision has already been sporadically used by other groups to access the heart.[13,14] The published series were, however, small and always confined to ASD closure. A posterolateral approach has also been proposed to close septum secundum defects.[15,16] We initially used this incision in a few patients but abandoned it. The incision severed 2 muscles of the chest wall, the heart was far away, and the atrial defect was difficult to expose. In the end, the incision was twice the length of our axillary incision.

Two factors, transesophageal echocardiography and the choice of appropriate surgical technique, have been instrumental in the successful implementation of our minimally invasive surgery program. Transesophageal echocardiography completes the view of the heart that the surgeon no longer has. It assesses ventricular fibrillation, detects ventricular dilatation or presence of air signal, and accurately evaluates the repair when a second CPB run is still possible. This happened 3 times in our experience and certainly contributed to the perfect repair achieved in practically all our patients.[17] Among established surgical techniques, the one best suited to the lateral approach was elected in this series. The great majority of ASDs have been closed directly with a running suture (a technique we had already adopted with sternotomies). The fact that the atria are dilated often allows a direct closure of the defect without tension on the suture line. Although we have restricted the use of a patch to large and to some sinus venosus defects, we agree that the liberal insertion of a patch is an acceptable alternative[1] that can also be routinely used with the axillary incision. We selected the technique that limited the time of ventricular fibrillation in the repair of abnormal return of the right superior pulmonary veins in the SVC. Ventricular fibrillation was restricted to the section and suture of the SVC and to the construction of the baffle patch. Finally, restrictive subaortic VSDs were closed either with a direct approach if the borders were easy to identify or after detachment of the anterior leaflet of the tricuspid valve[9] if they were cancelled by overgrowth tissue or by the tricuspid valve itself.

Conclusion

The right axillary incision provides a suitable access to the heart for the repair of a wide range of defects located at the atrial level and close to the atrioventricular junction. The functional and cosmetic results are unsurpassed by other surgical incisions and compare favorably with those obtained by using percutaneous techniques.

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